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Cutting bit for camshaft milling cutters and disc milling cutters for same

The present invention concerns a cutting bit for camshaft milling cutters and a corresponding disc milling cutter for camshaft milling. Corresponding cutting bits are already known in the state of the art, which comprise a substantially cuboidal cutting body with an upper face and a lower face substantially parallel thereto and which have side faces and cutting edges which are formed along the lines of intersection of those side faces with the top side and/or the underside.

The cutting bits can be square or also generally rectangular in plan. When mutually oppositely disposed side faces of such cutting bits extend substantially parallel to each other, that generally involves a negative rake angle, by virtue of the necessity for a relief surface behind the cutting edge. Cutting bits or cutting inserts of that kind are therefore also referred to for the sake of brevity as "negative cutting bits".

If the upper face is smaller than the lower face or vice-versa, then a cutting edge involving positive cutting geometry can be provided at the transition of the side faces which are then correspondingly inclined, in relation to the respective larger one of the upper and lower faces. The cutting bits according to the present invention can be both positive and negative cutting bits or inserts.

Rectangular or preferably square cutting bits of that kind are particularly extensively used on milling cutter heads for milling crankshafts and camshafts. For that purpose, suitable cutting bits are arranged along the periphery of a cylindrical main portion of a disc milling cutter and such a disc milling cutter is then caused to rotate about its axis and is moved in

a radial direction towards a crankshaft or camshaft which can possibly also be rotated about a longitudinal axis so that wide grooves are milled out of an initially relatively thick, solid metal shaft, in individual regions thereof, and the remaining parts thereof are profiled so that the overall result is the desired profile of a camshaft or also a crankshaft.

In that respect, particularly when dealing with camshafts, the situation very regularly sees the occurrence of a special profile shape which is provided between two spaced-apart grooves on a cam which can also be present in the form of an eccentrically displaced, cylindrical part. That profile is characterised by bevelling or chamfering of the edges, wherein a cylindrical part of slightly smaller diameter again adjoins one of those chamfers.

Such a profile can be seen on the part of a camshaft as is illustrated in Figure 1 at reference numeral 30 for two cylindrical, non-coaxial parts of a camshaft.

In this case, those parts do not necessarily have to be cylindrical but they can be of a cam contour which in principle can be any desired contour and which deviates from a circular shape which however is not visible in the view shown in Figure 1.

The production of corresponding profiles is relatively complicated and expensive with the cutting bits and milling cutter heads known in the state of the art, and conventionally, to produce a profile corresponding to the profile of the cam 30 in Figure 1, milling cutter heads with two displaced rows of cutting bits are used in order to produce the cylindrical part while two further bits are used for producing the chamfers or bevels and the short cylindrical attachment portion. Therefore, if such profiles are to be produced in one pass, it is necessary to provide mounting devices for four different rows of cutting bits along the periphery of a disc milling cutter which is in the basic shape of a cylindrical disc. Unless various types of cutting inserts are also to be used for that purpose, such

a disc milling cutter must have four different and in particular differently oriented rows of mounting pockets for suitable cutting bits. As moreover the cutting regions of such cutting bits must necessarily overlap in order to cover the entire profile, all those various cutting bit mountings have to be displaced relative to each other in the peripheral direction along the outside periphery of a disc milling cutter, which in turn means that the cutting bits which are to produce one and the same part of the profile must be at relatively large spacings relative to each other. That reduces the capacity and efficiency of corresponding milling cutters. Alternatively, it would be possible for the various parts of the profile to be produced in a plurality of working operations involving various milling cutter heads, which however is detrimental in terms of efficiency of production.

In comparison with that state of the art, the object of the present invention is to provide a cutting bit and a corresponding disc milling cutter which are simpler to produce and by virtue of the use of which it is possible to produce cam profiles with a straight main part (for example cylindrical) which is parallel to the axis, bevels at the edges and/or at one or both sides extension portions of smaller diameter, at a higher level of efficiency.

In terms of the cutting bit that obtain is attained in that the upper face and/or the lower face have at diagonally oppositely disposed corners raised corner regions which project above the plane of the respective upper face and lower face respectively and which extend as far as the side faces so that the cutting edges are at least partially formed by the lines of intersection of the side faces with the surfaces of the raised corner regions.

In other respects the remaining part of the cutting edges is formed in conventional manner between the line of intersection between an upper face or a lower face and the respective side faces. The cutting edge therefore comprises two cutting edge regions with in principle any

transitional region therebetween, the cutting edge regions being displaced in the direction of the thickness of the cutting bit (thickness = spacing between the upper and the lower faces).

If bevels or chamfers of edges are to be produced on the cam profile, then the transitional region should entail the corresponding inclination of the bevel face.

Such a cutting bit can be arranged at the periphery of a disc milling cutter in such a way that, apart from tilting through a relief angle which is to be set, the upper and the lower faces respectively are disposed parallel to a plane which is perpendicular to a radius vector, facing towards the cutting bit, of the cylindrical disc milling cutter. That means that the cutting edge part which is formed in the raised corner region of a cutting bit is at a somewhat greater spacing from the axis of the cylinder of the disc milling cutter than the remaining part which is formed between the upper and lower faces respectively and the side face, wherein at least the last-mentioned cutting edge part extends parallel to the axis of the disc milling cutter.

The transition between the cutting edge part in the raised region and the remaining region of the cutting bit bridges over that differing radial spacing from the axis of the cylinder of the disc milling cutter and thus, when milling a camshaft profile, it produces the bevelled part in the edge region of a cam.

If, as is provided in the preferred embodiment of the invention, the cutting bits according to the invention are of a mirror-image symmetrical configuration in relation to a diagonal (in plan view onto the upper or lower face), preferably being of a mirror image symmetry configuration in relation to both diagonals, then the cutting edge parts formed by the raised region, along adjacent side faces, are of respectively equal length, and the transitional regions are also of respectively equal length and involve the same inclination. This means that, when the cutting bit is

turned through 90° about an axis perpendicular to the upper and lower face, the relative arrangement of the raised region and the remaining cutting edge part is merely interchanged and accordingly a mirror-image profile is produced. Therefore, simply by turning the cutting bit through 90°, it is possible to use one and the same cutting bit both for the right-hand edge or bevel profile and also for the left-hand edge or bevel profile of a cam. If the raised region has a surface which is substantially parallel to the upper or lower face respectively of the cutting insert, then the cutting edge part provided thereon is operative to form a part of the cam face which is parallel to the main face of the cam but is of a smaller radius, that is to say for example the radius of the short cylindrical projection portion 36 in Figure 1.

Preferably, the cutting bits according to the invention are arranged along the two edges of a milling tool in the form of a cylindrical disc in mounting pockets which are arranged in mutually displaced relationship, in such a way that the raised regions respectively form the radially outward and also axially furthest outwardly disposed portions of the milling tool. That overall affords a profile as is shown at top right in Figure 1 in the form of a cutting profile 38 projecting over the cam profile. When the cutting bits are arranged in that way moreover the side faces respectively adjoining a cutting edge act as rake faces, in contrast to the conventional use of corresponding cutting bits in which the top side and the underside are each in the form of rake faces.

If the raised corner regions are provided at the top side and the underside of the cutting bit, then a total of eight usable cutting edges are available on each cutting bit, which cutting edges by rotation of the cutting bits through 90° about an axis extending perpendicularly to the upper and lower faces or about an axis extending perpendicularly to two side faces can be moved into their active cutting position, whereby firstly four of those cutting edges can be used and finally the cutting bits, after rotation

through 90° about the above-mentioned axis, along the one edge of the disc milling cutter in the form of the cylindrical disc, can also be replaced by those of the other edge, in which case then also the four remaining cutting edges can be successively moved into the active position by suitable rotation.

It will be seen that in that way it is possible to employ a single type of cutting bit and to make use thereof in a highly effective manner as each of those cutting bits has eight usable cutting edges. If however the desire is to provide the cutting edges only at the transition of the side faces to the upper face, there are still four cutting edges available by the cutting bits being turned or interchanged, and those cutting edges in their entirety always form the desired profile.

If the arrangement is restricted to cutting edges along the periphery of the upper face (and the associated corner regions), it is also possible to impart a positive cutting geometry to the cutting bit by the side faces being inclined, thereby forming a truncated pyramid shape. In that case, it is possible to provide a positive rake angle at the cutting edge, in spite of maintaining a suitable relief angle.

It will be appreciated that the width of a corresponding disc milling cutter is matched to the overall length of the cutting edges of the corresponding cutting inserts so that those cutting edges of the two different rows of cutting bits which are arranged along the respective edges of a milling cutter body in the form of a cylindrical disc overlap each other in the axial direction so that it is possible to produce the entire cam profile shown in Figure 1.

It will be appreciated however that the production of different profile shapes from those shown in the Figures is also made possible by differently shaping the raised regions, for example not in the form of a flat face parallel to the upper and lower face respectively.

It will further be appreciated that the size of the cutting bits or the

length of the respective cutting edges and the corresponding width of the disc milling cutter are matched to the profile which is to be specifically produced. In that respect however it is entirely possible to produce the same cam profile in different widths (or of different axial lengths) by using milling cutter heads of different widths or by virtue of different depths for suitable mounting pockets for the cutting bits, with one and the same type and one and the same size of cutting bits. In particular the cutting bits can be secured to the disc milling cutter axially displaceably (if necessary also radially displaceably or rotatably through small angles).

Desirably, the mounting devices or the mounting pockets on a disc milling cutter are adapted to receive a basically cuboidal cutting bit body, that is to say they have essentially three mutually perpendicular support faces of which one support face (apart from a relief angle which is to be set) is arranged substantially perpendicularly to a radius vector of the disc milling cutter, which faces towards that mounting pocket, one wall of the mounting pocket is in a plane substantially perpendicular to the axis of the disc milling cutter, and the third one (once again apart from tilting to produce a relief angle) is substantially parallel to a plane which is defined by the axis and the radius vector facing towards the mounting pocket.

In that respect, at least when using double-sided cutting bits, that is to say cutting bits which have cutting edges at the transition of the side faces both to the upper face and also to the lower face, at least the contact face which is approximately parallel to the radius vector should have an opening to receive the raised corner region of a cutting bit. That makes it possible moreover for the cutting bit to bear over a large area against the faces of appropriate mounting pockets and makes it possible for the raised regions and the cutting edges provided thereon not to be loaded in their non-active position within the mounting pockets.

Further advantages, features and possible uses of the present invention will be clearly apparent from the description hereinafter of a

preferred embodiment and the Figures relating thereto, in which:

Figure 1 shows a part of a camshaft having two cylindrical, non-concentric cams of a given cam profile,

Figure 2 shows various views of a first embodiment of a cutting bit with four negative cutting edges,

Figure 3 shows a cutting bit similar to Figure 2 but with positive cutting edges,

Figure 4 shows various views of a double-sided cutting bit with a total of eight usable cutting edges,

Figure 5 shows a diagrammatic perspective view of the cutting bit of Figure 4,

Figure 6 shows a section of a disc milling cutter having a plurality of cutting bits as shown in Figure 4 which are arranged thereon and accommodated in suitable openings, and

Figure 7 is a perspective view of two mounting pockets in a disc milling cutter for cutting bits as shown in Figures 4 and 5.

Referring to Figure 1, shown therein is a more or less diagrammatically illustrated part of a camshaft, with a shaft axis 40 and a cylindrical shaft part 20 which is concentric thereto. That cylindrical shaft part 20 is firstly produced independently of the cam contour by milling or turning.

Shown on both sides of the cylindrical shaft part 20 are cams 30 which in terms of their profile are in mirror image relationship with each other but in other respects are identical in configuration, while however being displaced in a radial direction in opposite directions with respect to the shaft axis 40.

The cams 30 can be circular in axial view thereonto, but they may also be of another peripheral contour. The cams 30 comprise a cylindrical main part 35 whose edges are bevelled on both sides along bevel faces 37. Also adjoining the bevel 37 at one side is a respective cylindrical part

36 which is of somewhat smaller diameter than the cylindrical main part 35 and which is also shorter. In the case of non-cylindrical cams, the contour which can be seen in Figure 1 is the same and the parts 35 and 36 are then of the same non-cylindrical contour in each case with the same stepped configuration or diametral difference.

It will be appreciated that the camshaft generally has more than two cams and more than one cylindrical part and that it can be envisaged as being correspondingly supplemented and extended in both directions. In that respect the individual cams 30 may also be eccentrically displaced in different directions with respect to the shaft axis 40.

The above-described cam contour occurs very frequently and on a regularly recurrent basis in camshafts. Conventionally, that contour could be produced only with a plurality of various cutting bits and often only in a plurality of working operations with separate milling cutters. Use of the cutting bits in accordance with the present invention, as are shown by way of example in Figures 2 to 5, in conjunction with a disc milling cutter as is diagrammatically illustrated in Figures 6 and 7, now makes it possible to produce the illustrated contour in a single working operation with a single milling tool and a single type of cutting bits. By way of example, Figure 1 shows the contour of two cutting bits 12 which are arranged in mirror image with respect to each other, wherein portions of the common cutting edge contour of both cutting bits 12 precisely involve or produce the desired profile of the cam 30. The mirror-image arrangement of two such cutting bits 12 is easily achieved by turning a cutting bit about its central axis through 90°, as will be described again hereinafter.

The cylindrical main part 35 is of an axial length a' which in principle can be varied as desired, only as long as it is less than the sum of the lengths a of the two straight cutting edge parts 5 of two cutting bits 12 (see Figure 4c).

Figure 2 shows as a first embodiment of the invention a cutting bit

10 as can be used for producing corresponding contours. The cutting bit 10 comprises a substantially cuboidal main portion 1 with an upper face 2 and a lower face 3 which are substantially parallel to each other and of a square configuration. Provided at two diagonally oppositely disposed corners of the upper face 2 are raised regions whose surface is substantially parallel but displaced in relation to the upper face, while inclinedly extending transitional faces 16 form the transition from the upper face 2 to the surface of the raised region 8. Also shown at the centre of the cuboidal main portion 1 (in Figure 2a) is a central fixing bore 15 which is conically enlarged in its upper region to receive a screw head.

Cutting edge parts 5, 6 and 7 are formed by the transition between the respective side faces 4 and the upper face 2 or the raised part 8 provided thereon, and the transitional faces 16. The profile configuration of the cutting edge parts 5, 6 and 7 can best be seen from Figure 2b which is a view from the left onto the cutting bit shown in Figure 2a. It is to be noted in this respect that the raised region 8 which can be seen at the bottom in Figure 2b is displaced rearwardly with respect to the plane of the paper, so that the cutting edge profile 5, 6 and 7 approximately corresponds to half of the profile shown in Figure 1. The other half of that profile is obtained simply by turning the cutting bit through 90° about the central axis 17, in which case then an adjacent side face 4 forms corresponding side edge parts with the top side 2 of the cutting bit or with the raised region and the transitional face so that overall the profile which is mirrored at the axis 17 in relation to Figure 2b appears, in which case the working region of the cutting edge parts 5 overlaps more or less if the condition $a' < 2a$ is satisfied.

In connection with Figure 6 this description will also explain hereinafter how, by suitably tilting the cutting bits 10, 11 or 12, this ensures that only the respective forwardly disposed cutting edge parts 5, 6 and 7 come into engagement with the surface of the cam to be

produced, while the further rearwardly disposed second raised corner region 8 of that cutting bit does not come into contact with the surface of the workpiece as long as that raised corner region is not rotated into an active position.

In the present case however, in contrast to conventional cutting bits, the rake face is not for example the surface 2, but rather in the use of corresponding cutting bits in accordance with the invention the chips go away on the side faces 4 while the surface 2, like the upper side of the raised region 8 and the corresponding transitional face 16, respectively form relief surfaces.

In that respect, if there is a wish to prevent the respectively rearward raised region coming into contact with the surface of the workpiece, the cutting bit has what is referred to as negative cutting geometry, that is to say the rake face which adjoins the cutting edge and which is formed by one of the side faces 4 forms a negative rake angle with respect to a line perpendicular to the produced surface of the workpiece.

Figure 3 shows a cutting bit in which the lower face 3 is smaller than the upper face 2, with the cutting edges being formed at the transition thereof to the side faces 4'. By virtue of that fact, the side faces 4' are inclined through an angle of inclination α with respect to the upper face 2 and the lower face 3 and overall define the face of a truncated pyramid (see Figure 3c which shows a view from above onto the cutting bit 11 shown in Figure 3a).

In that respect, in order to have a positive cutting geometry, the angle α must be larger than a tilt angle β which is to be described hereinafter and which ensures that the respectively rearward raised region 8 does not come into engagement with the surface of the workpiece.

Figures 4 and 5 show a cutting bit 12 in which the upper face 2 and the lower face 3 are substantially identical. In that case the upper face 2 precisely corresponds to the upper face 2 shown in Figure 2 while the

lower face 3 is of precisely the same structure and differs in that respect from the lower face 3 of the cutting bit shown in Figure 2. For use when milling a cam profile, there is only ever one set of cutting edge parts 5, 6 and 7 that come into engagement with the surface of the workpiece. Overall, there are eight such cutting edge sets available on the cutting bit 12, more particularly in each case four involving a given orientation of the raised parts 8 relative to the remaining regions. For example the view shown in Figure 4b is also achieved by turning the cutting bit 12 about the axis 17 and about the axis 18 in each case through 180°, which each time results in the same view as shown in Figure 4b which is thus to be achieved in four different positions (with in each case four different sets of active cutting edge parts 5, 6 and 7) of the cutting bit. The arrangement which is of a mirror image configuration for that purpose and in which the raised regions which can be seen at bottom right and bottom left in Figure 4b are not disposed at the rear but at the front and conversely the raised regions 8 which can be seen at top right and bottom left are behind the plane of the paper, is achieved by rotation through 90° about the axis 17, whereupon then the same view can again be reproduced by rotation through 180° about the axis 17 or about the axis 18 or about both.

In that respect Figure 4b corresponds to a view onto Figure 4a from the left and Figure 4c corresponds to the view onto Figure 4a from above.

It will be appreciated that because the upper face 2 is of an identical configuration to the lower face 3 the conical recessing of the fixing bore 15 is also provided from both sides.

As can also be seen from Figures 4a to 4c, the raised regions 8 on the underside 3 are arranged in relation to the raised regions 8 at the top side 2 at the 90°-displaced, mutually diagonally opposite corners of the cutting bit 12 which is square in plan. However, they could also readily be arranged at the same respective corners without this in any way adversely affecting the use of those cutting bits 12.

Figure 5 once again shows a perspective view of the cutting bit illustrated in Figure 4, but without any intention here to provide a true-to-scale view of such a cutting bit. It will be clearly seen from this perspective view that, depending on the respective orientation of the cutting bit and by rotation through 90° about the axis (not shown) through the bore 15, it is possible to interchange the relative orientation as between the cutting edge parts 5 and 6 so that the profile shown in Figure 1 can be readily embraced, with two successively arranged cutting bits.

Figure 6 shows a disc milling cutter with a row of cutting bits 12 arranged thereon. The milling tool is a relatively large cylindrical disc 55 having mounting pockets 50 for the individual cutting bits 12. The design configuration in principle of the mounting pockets 50 can be seen from Figure 7. R denotes the radius which is to produce the cylindrical contour 35 of a cam 30, that is to say the radial position of the cutting edge part 5 which extends parallel to the axis of the disc milling cutter 55. In a corresponding manner, the raised regions 8 with the cutting edge parts 6 project in a radial direction somewhat beyond that radius R, with the cutting edge part 7 forming the join between the parts 5 and 6.

As can also be seen from Figure 6, the cutting bits 12 are tilted with respect to the peripheral surface of the cylindrical disc 55 (or in other words, with respect to a plane perpendicular to the respective radius vector), through an angle β which ensures that the respective rearward raised corner region 8 is within the radius which is cut by the cutting edge part 5. In the orientation illustrated here, the cylindrical disc 55 rotates in the counter-clockwise direction about an axis which is perpendicular to the plane of the paper and from which the radius vector R extends.

If the positive cutting bits 11 are used instead of the cutting bits 12, it is to be noted that the tilt angle β is smaller than the angle of inclination α shown in Figure 3 for the side faces 4' relative to the upper face 2 of the cutting bit 11 if a positive cutting geometry is to be guaranteed.

With the orientation shown in Figure 6, the side face which is identified by way of example with reference numeral 4 on one of the cutting bits 12 is the rake face of the cutting edge parts 5, 6 and 7 which are just active at that time and which are extending substantially perpendicularly to the plane of the paper.

It will be appreciated that the mounting pockets 50 for the individual cutting bits are of such a design configuration that the chips produced can be easily carried away.

A section from a disc milling cutter 55 with the corresponding mounting pockets 50 is diagrammatically shown once again in Figure 7, together with the cutting bits 12 which are illustrated thereabove and therebeneath respectively and which are to be respectively arranged therein, in the respectively required orientation. The mounting pockets 50 essentially have three mutually perpendicularly disposed side walls 51, 52 and 53, wherein the side walls 51 and 52 come into engagement with two adjacent side faces 4 of a cutting bit 12 while the side face 52 comes into engagement with a top side 2 or an underside 3 of the cutting bit 12. Not shown in this case are the fixing bores 15 for the cutting bits 12 and the corresponding screwthreaded bores which are provided in the walls 53.

As will also be seen, the face 53 is also provided with an additional opening 54 in which the respective corner region 8 of the cutting bit 12, which is present in that region, can be received. The opening 54 is desirably produced by a suitable bore which – disregarding the fact that the structure is not shown true to scale in Figure 7 – is at any event of such a dimension that the raised corner region 8 disposed there can at any event be received completely in the opening 54. The corner at the transition of the faces 52/53 is also bored out for relief clearance. Depending on the respective depth of the mounting pockets 50, that is to say in particular the axial dimension of the walls 52 and 53, the diagonally oppositely disposed upper region of the wall 53 may also have a

corresponding mounting pocket for the raised corner region 8, which is disposed there, of one of the sides of the cutting bit 12. If the cutting edge part 5 however is longer than corresponds to the axial length of the walls 52 and 53, that corner region does not come into engagement with the wall 53.

As can also be seen by looking at Figure 7, the rear wall 53 of the mounting pocket extends somewhat inclinedly with respect to the peripheral surface of the cylindrical disc 55 and the rear wall 52 also correspondingly extends inclinedly relative to a plane defined by the radius vector and the axis of the disc 55, in order to ensure that, in the case of the above-discussed cutting bit 12, the raised corner region 8 which can be seen at bottom left lies radially within the cutting edge part 5 which can be seen from the right. A corresponding consideration also applies for the cutting bit shown at bottom right, in which the corner region 8 which can be seen at top left must also be disposed radially within the cutting edge part 5 which can be seen at the right, more specifically by a dimension δ, as is indicated in Figure 6.

It will be appreciated that the mounting and holding devices for the cutting bits 10, 11 or 12 can also be of different configurations and in particular in such a way that the individual cutting bits are adjustable, that is to say they can be set in their radial but in particular in their axial position (with respect to the axis of the disc milling cutter 55). By axial adjustment of the cutting bits, that changes the dimension a' of the cam 30, in which respect the amount of adjustment in principle can vary between the value zero and at a maximum the value 2a, wherein a corresponds to the length of the cutting edge part 5.

However, a certain degree of overlap of the cutting edge parts 5 of the two cutting bits 12 arranged on different sides of the disc milling cutter 55 is always preferred. In particular, their cutting edges can be somewhat recessed or bevelled in the corner regions, at the corners 9' at which respectively adjacent cutting edge parts 5 meet, as that region is

always cut by a region, overlapping therewith, of the next following cutting bit.

The cutting bits are fixed in position by countersunk head screws which engage through the fixing bore 15 and which are screwed into corresponding screwthreads in the wall 53 of a mounting pocket 50 or into some other corresponding mounting arrangement. A particularity of the cutting bits 10, 11 and 12 according to the invention in that respect is that the axis of the fixing bore 15 does not extend through the rake faces but substantially parallel to the planes of the rake faces which in this case are identical to the side faces 4 and 4′. That permits relatively simple fixing in substantially radial bores at the periphery of the disc milling cutter or at the bottom of the faces 53 in the mounting pockets 50, as the axis of the fixing bore 15 extends substantially parallel to the side faces or rake faces 4, 4′, that is to say approximately in a radial direction. That makes it possible to arrange the cutting bits in a very close pitch relationship, that is to say at very short successive spacings. As in a corresponding fashion more cutting bits can be arranged at the periphery of a disc milling cutter of given diameter, that considerably enhances the efficiency (that is to say the milling capacity) of the milling tool.